

# PATENT SPECIFICATION

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## PROVISIONAL SPECIFICATION

### Improvements relating to Instruments for Detecting Conditions likely to Result in the Formation of Ice

We, NATIONAL RESEARCH DEVELOPMENT CORPORATION, a British Corporation, established by Statute, of 1, Tilney Street, London, W.1, do hereby declare the nature of this invention to be as follows:—

This invention relates to instruments for detecting conditions likely to result in the formation of ice. Such instruments are of particular value in connection with aircraft, where they may be employed to warn the crew of the onset or cessation of conditions likely to result in the formation of ice and/or to initiate, or cause the discontinuation of, an operation calculated to prevent or reduce the accretion of ice upon the airframe or within the power plant. The instruments may also be used to indicate and/or record the severity of icing conditions.

The invention is based upon the fact that the temperature of a heated body when exposed to conditions of icing is much lower than it is in clear air. This is due, primarily, to the evaporation of water from the surface of the body. The change in temperature depends upon the amount of water which strikes the body and, in conditions of icing, therefore, is related to the severity of such conditions.

In an instrument in accordance with the invention, provision is made for measuring and comparing the temperatures of two surfaces each of which is heated to a temperature above that of the ambient atmosphere, one surface being directly exposed to the impingement thereupon of moisture carried in the atmosphere and the other being open to the free circulation of air but screened against the deposition of moisture therefrom. The two heated surfaces may be screened and unscreened surfaces of the same body or two separate bodies may be employed; in either case, the same or separate sources

of heat may be utilized in heating the respective surfaces. The arrangement may be such that the comparison of the temperatures of the screened and unscreened surfaces results in the giving of an indication and/or record and/or the effecting of some operation when the difference in temperature exceeds or falls below a predetermined value.

Since the difference in temperature between the two heated surfaces (or a change in the difference in temperature in cases in which the surfaces are at different temperatures in clear air) is due to the deposition of moisture upon the exposed surface, it is possible that the predetermined difference in temperature may be attained under conditions of effective temperature such that ice accretion would not, in fact, result. It is preferred, therefore, to incorporate in the instrument means for measuring the temperature of the air or of equipment exposed to it at the point concerned; when the instrument is employed in the automatic control of apparatus for combating ice, such additional temperature-measuring means may form part of an over-riding control which permits actuation of the apparatus only when the actual temperature experienced at the point to be protected approaches freezing point.

When the two heated surfaces are on separate bodies, the latter need not be of the same shape or size and it is not necessary for the two surfaces to be heated to the same temperature in clear air conditions; it is sufficient if, in clear air, the change in temperature with change in rate of air flow is approximately the same for both surfaces.

In a particular example of an instrument in accordance with the invention, the surfaces of which the temperatures are compared are those of different por-

tions of a cylindrical heater element comprising resistance wire embedded in insulating material having an outer metallic sheathing. The heater element projects  
5 from the side of the carrying aircraft and has forward and rear lengths whose longitudinal axes are situated at right-angles to the air flow; the portion of the element intermediate the forward and rear lengths  
10 is bent to form an anchorage to which may be soldered a screen for preventing the direct impact of the air stream upon

the rear length. Thermo-couples secured to the surfaces of the forward and rear lengths form part of an electrical circuit  
15 whereby the temperatures of the two surfaces are compared.

Dated this 19th day of July, 1949.

F. J. HICKS,  
Chartered Patent Agent,  
Agent for the Applicant.

## COMPLETE SPECIFICATION

### Improvements relating to Instruments for Detecting Conditions likely to Result in the Formation of Ice

We, NATIONAL RESEARCH DEVELOPMENT CORPORATION, a British Corporation, established by Statute, of 1, Tilney Street, London, W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the  
20 following statement:—

This invention relates to apparatus for detecting conditions likely to result in the formation of ice from the atmosphere.  
30 Such apparatus is of particular value in connection with aircraft, where it may be employed to warn the crew of the onset or cessation of conditions likely to result in the formation of ice on the aircraft  
35 and/or to initiate or cause the discontinuance of an operation calculated to prevent or reduce the accretion of ice. The apparatus may also be used to indicate and/or record the severity of icing  
40 conditions.

The invention is based upon the fact that the temperature of a constantly heated body when exposed to conditions of icing is much lower than it is in dry air.  
45 This is due, primarily, to the evaporation of water which collects on the surface of the body. The temperature difference depends on the rate of evaporation of water which collects on the body and, in  
50 conditions of icing, therefore is related to the severity of such condition.

According to the invention, apparatus for detecting atmospheric conditions conducive to the formation of ice on a body  
55 moving through the air comprises two heated elements against one of which air may impinge directly, means for freeing air of substantially all of any droplets of water suspended in it and then causing it  
60 to impinge against the second heated element, temperature responsive means associated with each element, and means for supplying each element with heat at

a constant rate. The apparatus may be arranged so that there is a constant  
65 difference between the temperature of the two elements, so long as the air impinging or both of them is substantially free from droplets of water, means being provided to respond to the change in this  
70 difference resulting from the presence of droplets of water in the air impinging on one of them. The heated elements upon which the air impinges may be cylindrical with an internal axially disposed electrically heated resistance wire or coil  
75 separated therefrom by refractory material, or preferably may be of wire the resistance of which varies with temperature, backed by and insulated from the electrical heating means. With this  
80 latter arrangement the element against which air impinges directly may comprise a wire formed into a series of narrow elongated loops, lying in a plane or  
85 curved surface, and covered by thin sheet material upon which the air impinges. The difference in temperature of the heated elements when equally heated or  
90 the change in the difference between their temperatures if not equally heated, may be measured by means of thermo couples or by utilizing electrical resistance change according to the arrangement used, bridge  
95 circuits being preferably employed in either case.

In order to prevent the formation on the exposed heated element of water in the spheroidal state which may be removed  
100 without being evaporated from the surface of an element the working temperature of the latter should not exceed about 80° C. In order to remove droplets of water from the air which is caused, by the movement of the apparatus to impinge on the second  
105 heated element, the body of the apparatus may be heated where the air stream passes over it. The indicating and/or recording instruments used with the apparatus may

be made to function only when the latter is in motion and when the ambient temperature is such that the formation of ice is possible.

6 An apparatus in accordance with one form of the invention is shown in the accompanying diagrammatic drawing of which:—

10 Figure 1 is a sectional side elevation, and

Figures 2 and 3 are fragmentary detail views drawn to an enlarged scale.

The heated element against which air impinges directly comprises an electrically heated resistance 1 embedded in insulating material 3a which also secures the temperature sensitive resistance 2 so as to leave part of its surface bare the latter being covered by thin sheet material 3 as shown in detail in Figure 2. The heated element 2 is bent-up from wire to the form shown in Figure 3 as is also the heater 1; the heater element 2 together with the circular heated element 7 is connected so as to form two arms of a resistance bridge having means for indicating their difference or change in difference of temperature. The rear element comprises a heating wire 6 surrounded by refractory material and axially disposed within the conducting cylinder 7 the resistance of which latter varies with temperature. The forward element may be replaced by a cylindrical element similar to the element 7 and change of temperature measured by means of thermo couples or both elements may be of either type and the change in temperature derived from the changes of resistance of the conductors. The body of the apparatus consists of two parts 8 and 9 between the forward edges of which the water evaporating element 2 is situated. A partition 10 seals off the fore portion which contains conducting cylinders 11 and 12 in metallic contact with each other and with the body portions 8 and 9 respectively. Electrically heated wires 13 and 14 surrounded by refractory material supply heat to the body portions 8 and 9. The rear heated element 7 is situated between two plates 15 and 16 shaped so as to form a rectangular orifice at their rear edges and to fit between the portions 8 and 9 so as to leave rectangular passages 17 and 18 from which air is drawn during movement through the air causing air to enter the rear aperture 19 and impinge on the conductor 7. The air entering the aperture 19 is drawn from the spaces between the surfaces of the plates 15 and 16 and the airstreams leaving the surfaces

of the parts 8 and 9 respectively, in these spaces the air is in a turbulent condition and relatively free from water droplets since any water which is not evaporated by the heated surfaces 8 and 9 accumulates on their rear edges and is carried away by the air streams.

What we claim is:—

1. Apparatus for detecting atmospheric conditions conducive to the formation of ice on a body moving through the air comprising two heated elements against one of which air may impinge directly, means for freeing air of substantially all of any droplets of water suspended in it and then causing it to impinge against the second heated element, temperature responsive means associated with each element and means for supplying each element with heat at a constant rate.

2. Apparatus as claimed in Claim 1 wherein the arrangement is such that there is a constant difference between the temperatures of the two elements, respectively, so long as the air is substantially free from droplets of water, means being provided to respond to such change of this temperature difference as will result from the presence of water droplets in the air.

3. Apparatus as claimed in Claim 1 or 2 wherein the element against which air may impinge directly is in the form of thin sheet material backed by wire whose electrical resistance varies with temperature.

4. Apparatus for detecting atmospheric conditions conducive to the formation of ice on a body moving through the air having a casing which is divided internally into front and rear portions, the front portion containing a heater by which its walls are heated and having a heated element against which air may impinge directly mounted at the front thereof; the rear portion containing another heated element and being open to the ambient atmosphere at the front and at the rear thereof and the cross sectional configuration of the casing as a whole and the openings of the rear portion to the atmosphere being such that when the casing is moved forwardly through the air an aerodynamic action takes place whereby air is drawn from the front of the rear portion and is replaced by air entering from the rear of the rear portion so as to impinge on the heated element therein.

5. Apparatus for detecting atmospheric conditions conducive to the formation of ice on a body moving through the air sub-

stantially as hereinbefore described and as  
illustrated by the accompanying draw-  
ings.

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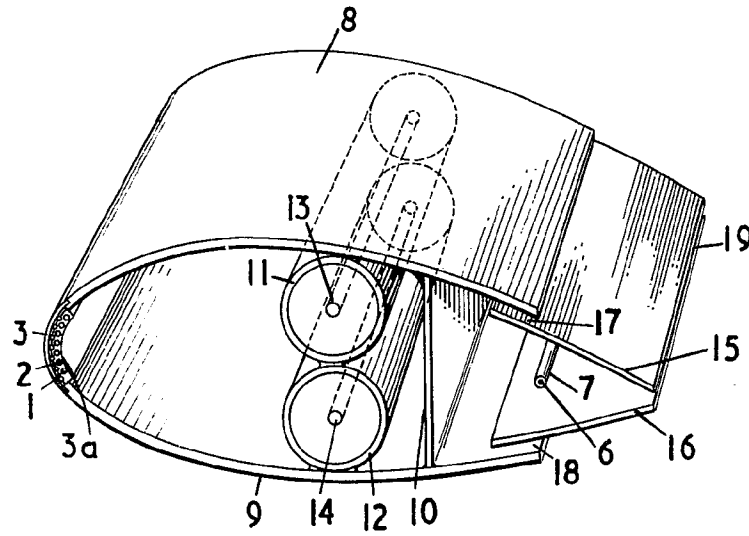


Fig. 1.

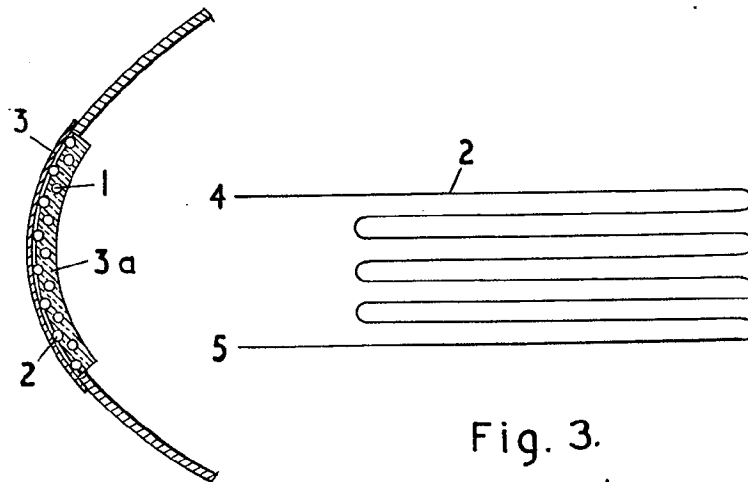


Fig. 2.

Fig. 3.